A hybrid system uses both digital modulation and frequency hopping techniques at the same time on the same carrier. This is similar to the combination DTS/FHSS system described above in the first example but the system is subject to slightly different standards. As indicated in Section 15.247(f), a hybrid system must comply with the power density standard of 8 dBm in any 3 kHz band when the frequency hopping function is turned off. The transmission also must comply with a 0.4 second/channel maximum dwell time when the hopping function is turned on. There is no requirement for this type of hybrid system to comply with the 500 kHz minimum bandwidth normally associated with a DTS transmission; and, there is no minimum number of hopping channels associated with this type of hybrid system. However, the hopping function must be a true hopping system, as described in Section 15.247(a)(1). The specific requirements in Section 15.247(a)(1) are: 1) A minimum channel separation. 2) Pseudorandom hop sequence. 3) Equal use of each frequency. 4) Receiver matching bandwidth and Synchronization. The additional requirements in Section 15.247 for a hybrid transmitter include the requirements the 1 watt output limit and RF safety requirements in Section 15.247(b) and the spurious emission limits of Section 15.247(c).

Supporting Images:

ID	Description	File Type

RECEIVED

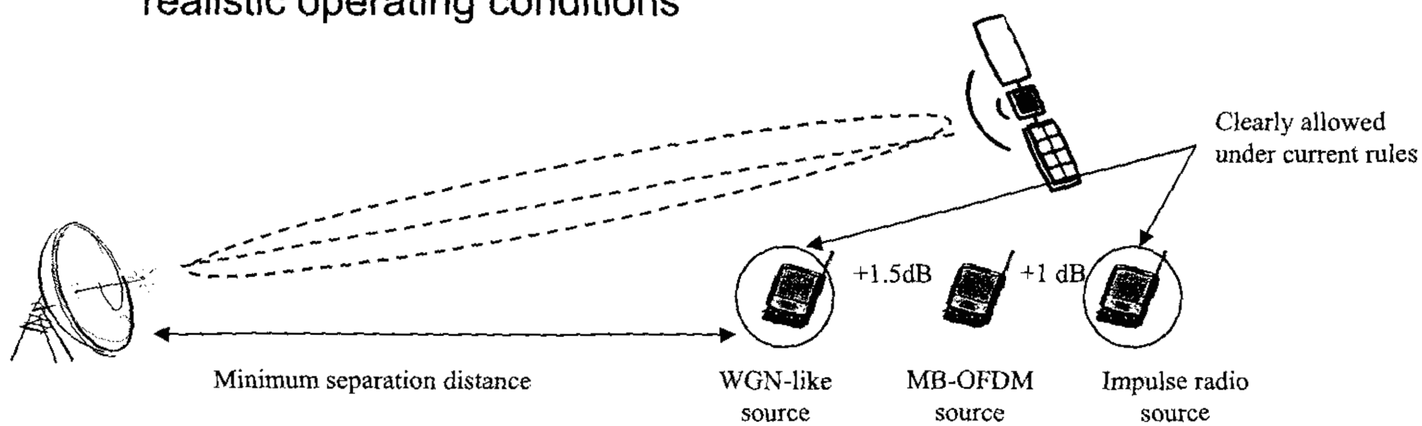
SEP - 9 2004

Federal Communications Commission
Office of the Secretary

ATTACHMENT A

Executive Summary of Results

- Analysis, simulations, and measurements for wideband fixed satellite services (FSS) systems all come up with the same results
  - Interference from MB-OFDM waveforms is actually less than levels of interference caused by waveforms already allowed by the rules
  - Differences between all waveforms is on the order of 2-3 dB
- There is virtually no difference between DSSS, WGN, MB-OFDM, and impulse-UWB waveforms into narrowband receivers (less than 2.5 MHz)
- MB-OFDM waveforms can cause less interference than impulse radios in wideband receivers
  - MB-OFDM is ~ 1 dB better than 1 MHz PRF impulse radio
- WGN can cause less interference than MB-OFDM into wideband receivers
  - Difference between MB-OFDM and WGN interference is less than *1.5 dB* under realistic operating conditions



Substantial Interference Margin Exists with Current FCC Limits

- FCC/NTIA Interference results for various US government systems: Table taken directly from Final R&O and using the indoor mask

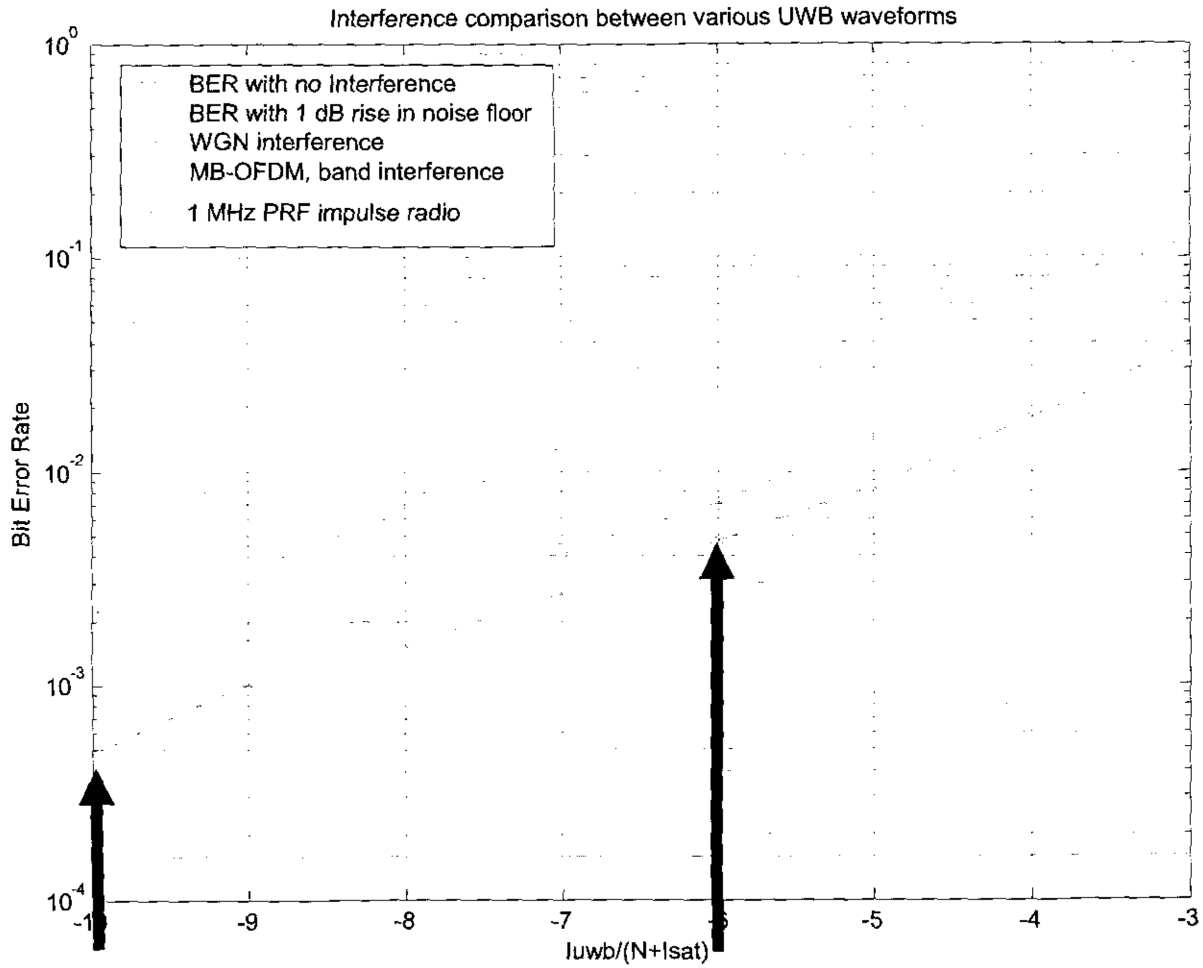
Most systems have substantial margin available

System	Frequency (MHz)	Maximum UWB EIRP (dBm/MHz) UWB Indoors 2 m height	Maximum UWB EIRP (dBm/MHz) UWB Indoors 30 m height	IF Bandwidth	Margin from current Part 15 limits
ARSR-4	1240-1370	-52	-73	690 KHz	23.3 dB (2 m) 2.3 dB (30 m)
SARSAT	1544-1545	-60	-57	800 KHz	15.3 dB (2 m) 18.3 dB (30 m)
ASR-9	2700-2900	-37	-57	653 KHz	14.3 dB (2 m)
NEXRAD	2700-2900	-33	-67	550 KHz	18.3 dB (2 m)
Marine Radar	2900-3100	-34	-45	4-20 MHz	17.3 dB (2 m) 6.3 dB (30 m)
FSS, 20 degrees	3700-4200	-24	-30	40 MHz	17.3 dB (2 m) 11.3 dB (30 m)
FSS*, 5 degrees	3700-4200	-39	-65	40 MHz	2.1 dB (2 m)
CW Altimeters	4200-4400	37	Not Applicable	N/A	78.3 dB (2 m)
Pulsed Altimeters	4200-4400	26	Not Applicable	30 MHz	67.3 dB (2 m)
MLS	5030-5091	-42	Not Applicable	150 KHz	-
TDWR	5600-5650	-23	-51	910 KHz	18.3 dB (2 m)

***: Most Direct TV/DSS/DTH receivers usually do not operate in 3.7-4.2 GHz C-band. They operate in 10.7-12.2 GHz Ku-band**

Fixed FSS performance results

- For a given performance, what is the increase in separation distance needed to maintain the same FSS performance?
  - 35 MHz symbol rate, 7/8 code rate, no interleaving, Es/(N+Isat)=7.6 dB (at sensitivity)



*Iuwb/(N+Isat) = -10 dB results in Iuwb/N = -6 dB which is a level defended by XSI in a contribution submitted to the FCC

0.5 dB rise in (N+Isat) *

1 dB rise in (N+Isat)

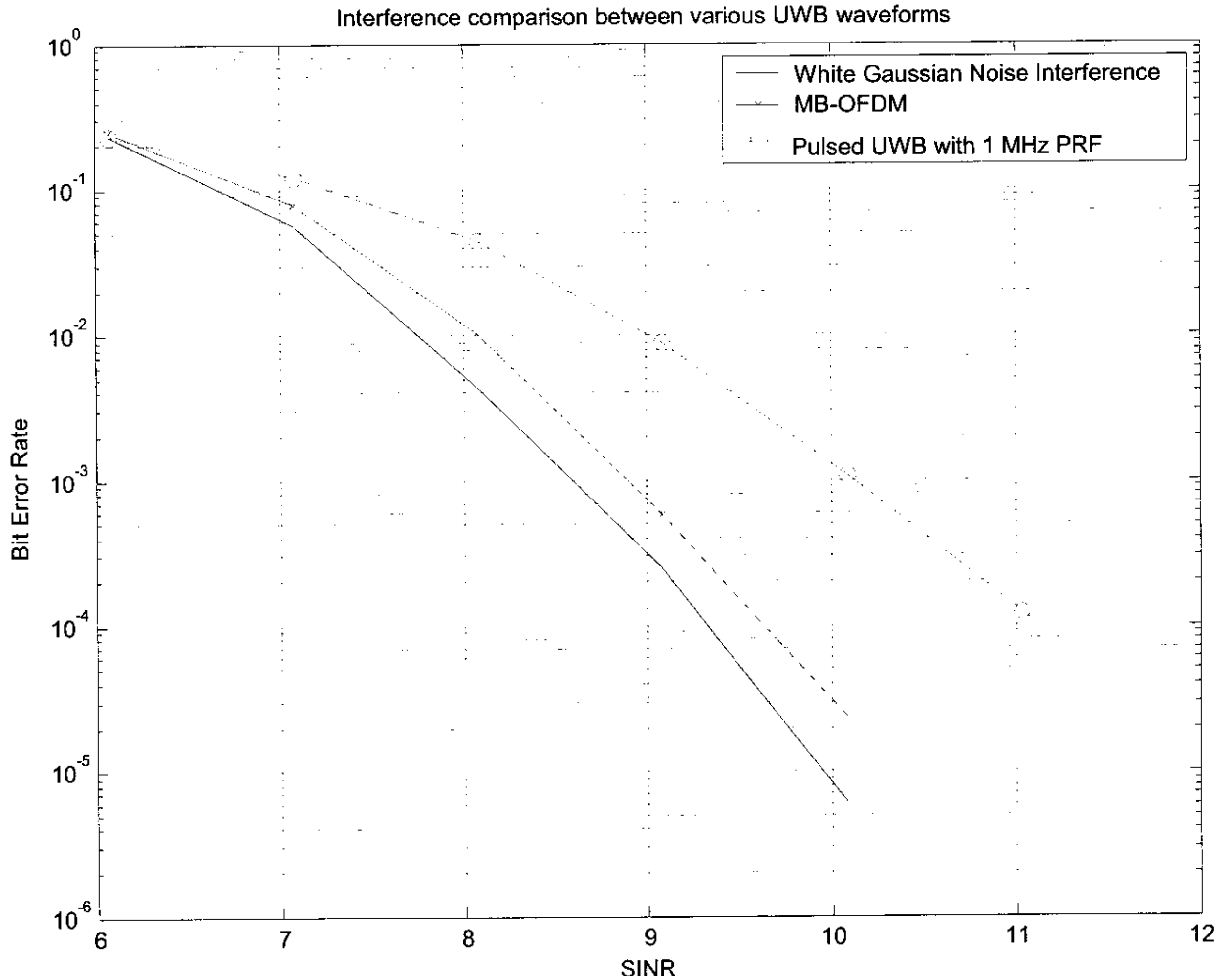
Fixed FSS performance results

- For a given performance, what is the increase in separation distance needed to maintain the same FSS performance?
  - Fixed FSS receiver performance (BER equivalent to 1 dB rise in SINR): 7/8 code

Interference Source	dB from WGN	Increase separation dist. (rel. to WGN, free space)	Increase separation dist. (rel. to WGN, path loss exp. = 3)
WGN	-	-	-
MB-OFDM	1 dB	12 %	8 %
1 MHz PRF Impulse	2.5 dB	33 %	21 %

Fixed UWB device separation distance

- For a given UWB device separation, what is the impact on FSS link margin?
  - 35 MHz, rate 7/8 coding, no interleaving, Iuwb/(N+Isat)=-4 dB



Fixed UWB device separation distance

- For a given UWB device separation, what is the impact on FSS link margin?
  - *Fixed Separation distance (BER = 10e-3) : 7/8 code (no interleaving)*

Interference Source	Iuwb/(N+Isat)	Reduced FSS Margin (dB)	Difference from WGN (dB)
WGN	-10 dB	0.5 dB	-
	-6 dB	1 dB	-
	-4 dB	1.5 dB	-
MB-OFDM	-10 dB	0.5	0
	-6 dB	1.1	0.1
	-4 dB	1.75	0.25
1 MHz PRF pulse	-10 dB	0.75	0.25
	-6 dB	2	1
	-4 dB	3	1.5

Absolute Separation Distance Results

- What is the absolute separation distance required between a UWB device (modeled here as WGN) and a FSS receiver?
  - What is the impact of assumptions used in the analysis?

Indoor parameters (includes 12 dB building attenuation factor)

Assumptions	Case 1 (Baseline)	Case 2	Case 3	Case 4	Case 5
		Changing 1 assumption at a time →			
Antenna Gain[1]	32-25log(θ)	**29-25log(θ)**	**29-25log(θ)**	**29-25log(θ)**	**29-25log(θ)**
Isat/N ratio[2]	-100 dB (no Isat)	-100 dB (no Isat)	**1.4 dB**	**1.4 dB**	**1.4 dB**
Path loss model	Free space (n=2)	Free space (n=2)	Free space (n=2)	**NLOS Path loss exp. (n=3)**	**NLOS Path loss exp. (n=3)**
Iuwb/(N+Isat) criteria	-10 dB	-10 dB	-10 dB	-10 dB	**-6 dB**

[1] Antenna gain in Case 1 proposed by SIA, gain in Case 2 proposed by XSI based on FCC 25.209 and ITU-R S.580.
[2] Isat/N = 1.4 dB derived from SIA filing to FCC, May 2003.

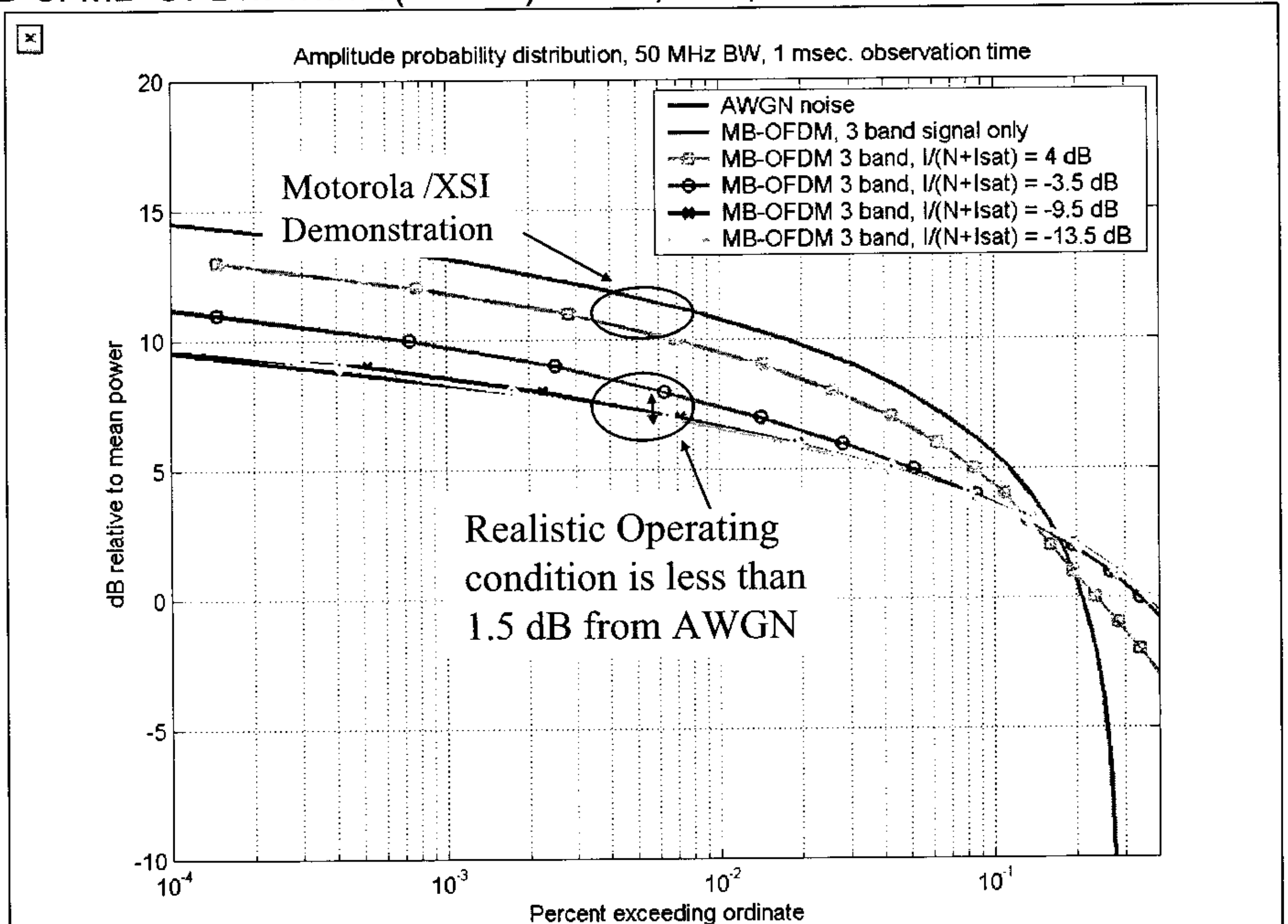
Absolute Separation Distance Results

20 degree indoor FSS Interference Table	Case 1	Case 2	Case 3	Case 4	Case 5
Tx Power	-41.30	-41.30	-41.30	-41.30	-41.30
FSS Antenna angle (deg.)	20.00	20.00	20.00	20.00	20.00
Antenna Gain	-0.53	-3.53	-3.53	-3.53	-3.53
Center freq. (GHz)	3.75	3.75	3.75	3.75	3.75
Breakpoint (BP) (m)	1.00	1.00	1.00	1.00	1.00
Building attenuation (dB)	12	12	12	12	12
Rx power at BP (dBm)	-85.75	-88.75	-88.75	-88.75	-88.75
Noise floor (N) (dBm)	-117.00	-117.00	-117.00	-117.00	-117.00
Isat/N ratio (dB)	-100.00	-100.00	1.40	1.40	1.40
(N+Isat) floor (dBm)	-117	-117	-113.234	-113.234	-113.234
Iuwb/(N+Isat) criteria (dB)	-10	-10	-10	-10	-6
Max. Iuwb (dBm)	-127	-127	-123.234	-123.234	-119.234
Path loss required (dB)	29.25	26.25	22.49	22.49	18.49
Path loss exp. after BP	2	2	2	3	3
Min. separation dist (m)	29.013	20.53963	13.31279	5.617107	4.132182

~17 dB difference depending on system assumptions
(vs. 1-3 dB difference depending on structure of UWB waveform)

APD[1] for MB-OFDM with different I/(N+Isat)

- The APD of MB-OFDM with I/(N+Isat) = -3.5, -9.5, -13.5 is less than 1.5 dB from AWGN.



[1] *Many modern digital receivers use elaborate error correction and time-interleaving techniques to correct errors in the received bit sequence. In such receivers, the corrected BER delived to the user will be substantially different from the received BER. Computation of BERs in these receivers will require much more detailed interference information than is contained in the APDs.* [R. Achatz, NTIA, Appendix A. Tutorial on Using Amplitude Probability Distributions to Characterize the Interference of Ultrawideband Transmitters to Narrowband Receivers]

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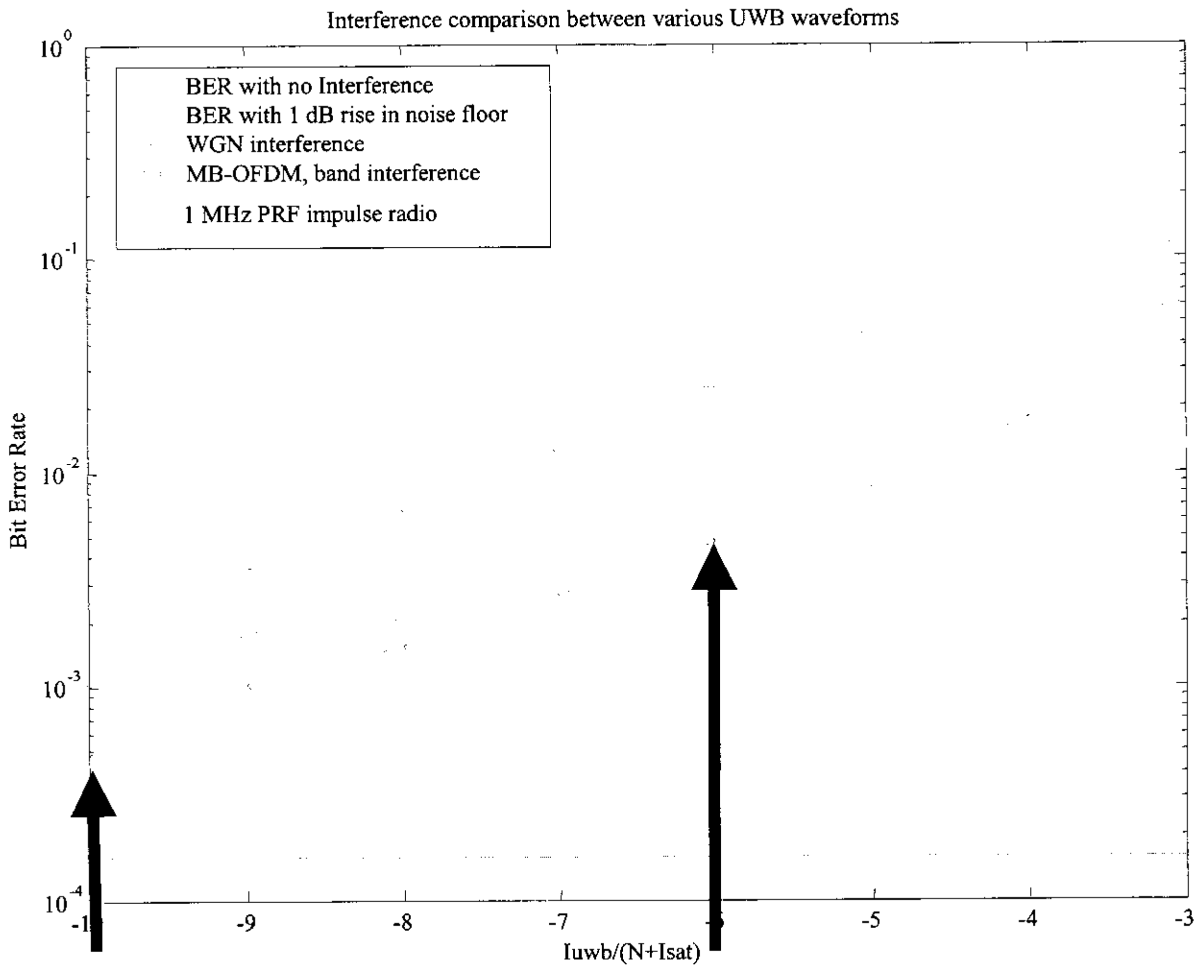

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Fixed UWB device separation distance

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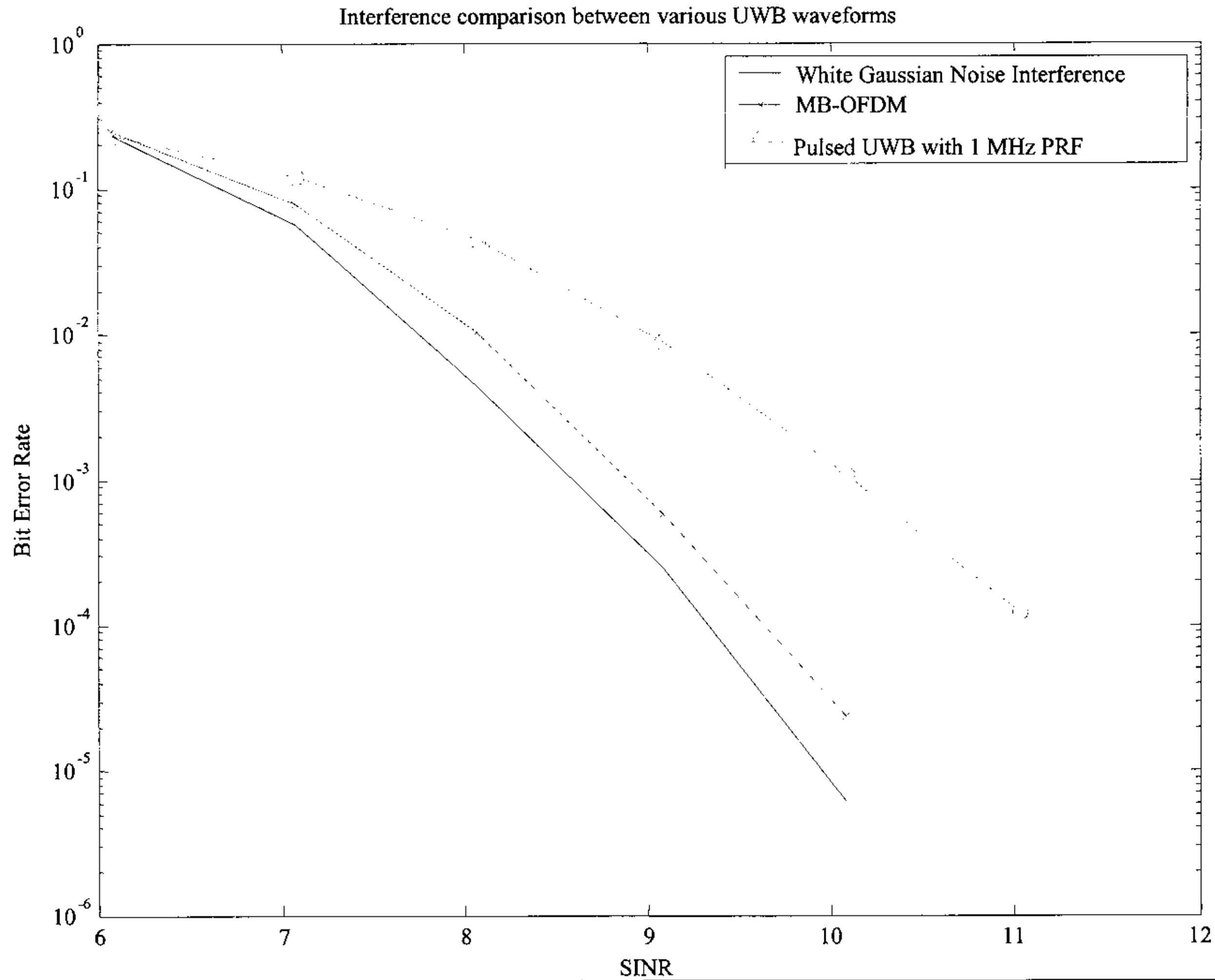
  - 35 MHz, rate 7/8 coding, no interleaving, Iuwb/(N+Isat)=-4 dB



Absolute Separation Distance Results

- What is the absolute separation distance required between a UWB device (modeled here as WGN) and a FSS receiver?
  - What is the impact of assumptions used in the analysis?

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Iuwb/(N+Isat) criteria	-10 dB	-10 dB	-10 dB	-10 dB	**-6 dB**

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Building attenuation (dB)	12	12	12	12	12
Rx power at BP (dBm)	-85.75	-88.75	-88.75	-88.75	-88.75
Noise floor (N) (dBm)	-117.00	-117.00	-117.00	-117.00	-117.00
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(N+Isat) floor (dBm)	-117	-117	-113.234	-113.234	-113.234
Iuwb/(N+Isat) criteria (dB)	-10	-10	-10	-10	-6
Max. Iuwb (dBm)	-127	-127	-123.234	-123.234	-119.234
Path loss required (dB)	29.25	26.25	22.49	22.49	18.49
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~17 dB difference depending on system assumptions
(vs. 1-3 dB difference depending on structure of UWB waveform)

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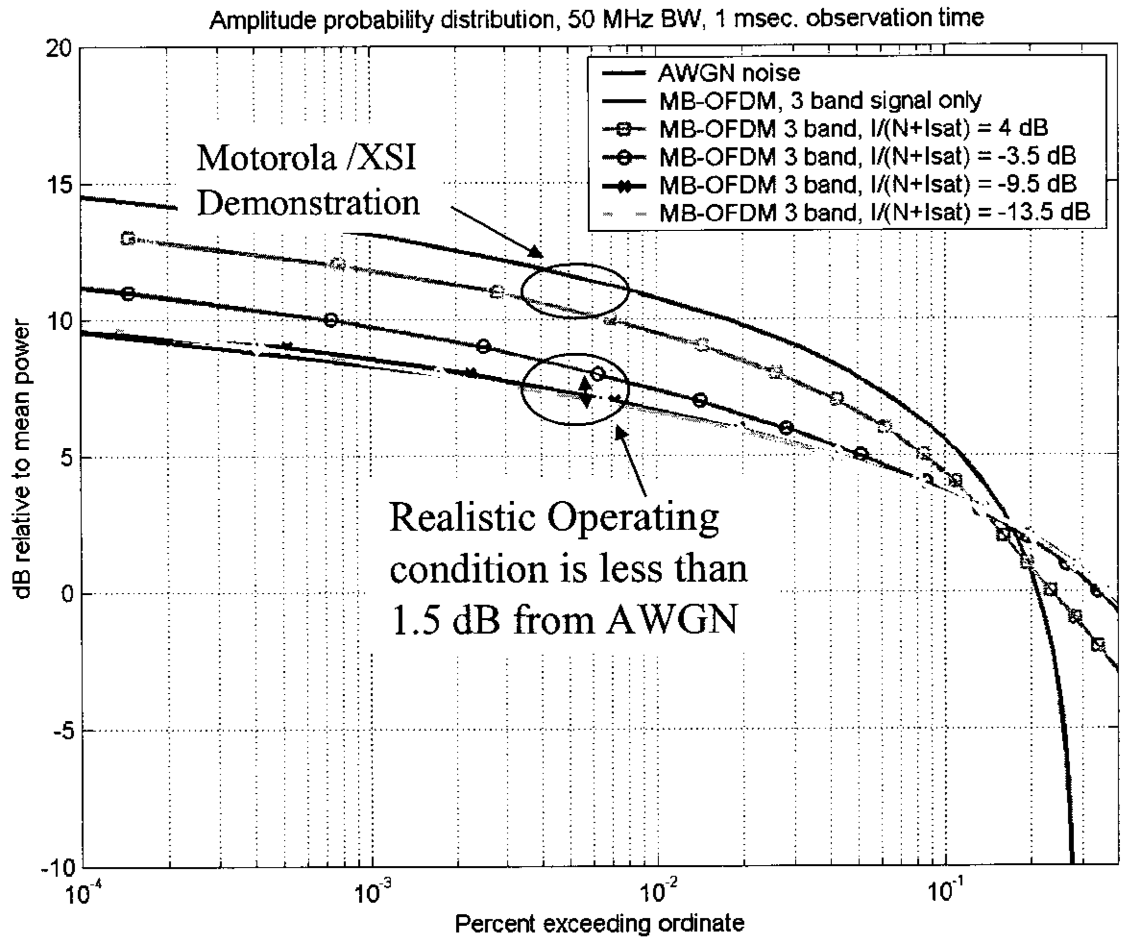

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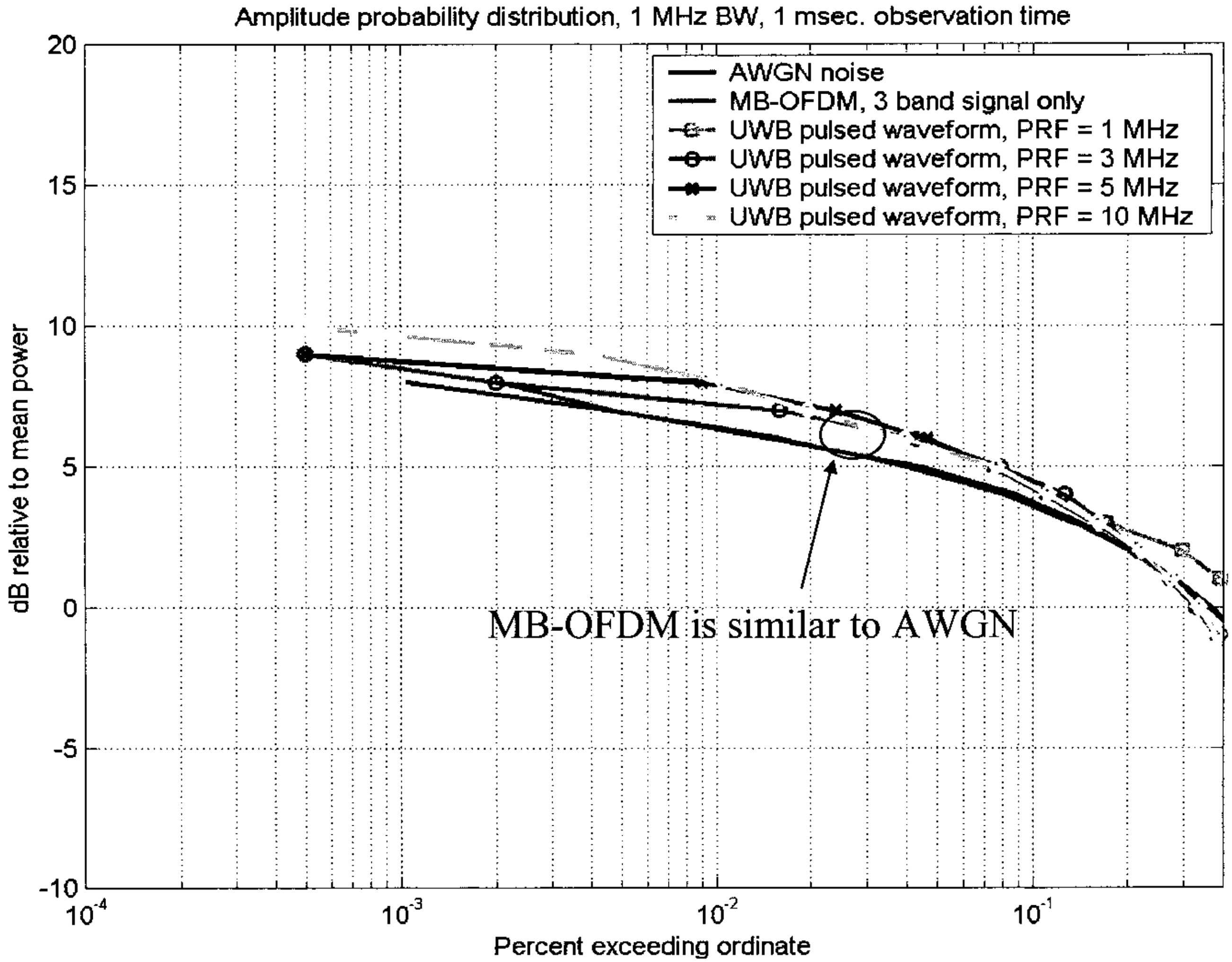
APDs for narrowband receivers

- MB-OFDM APD is similar to AWGN with a 1 MHz resolution bandwidth.



FCC Testing

- FCC tests were performed on two different MB-OFDM radios
- Test were performed at TDK RF Solutions EMC Test Services Lab.

  FCC Registration No.: 94066

  NVLAP Accreditation No.: 200430-0

- Measurements Performed:

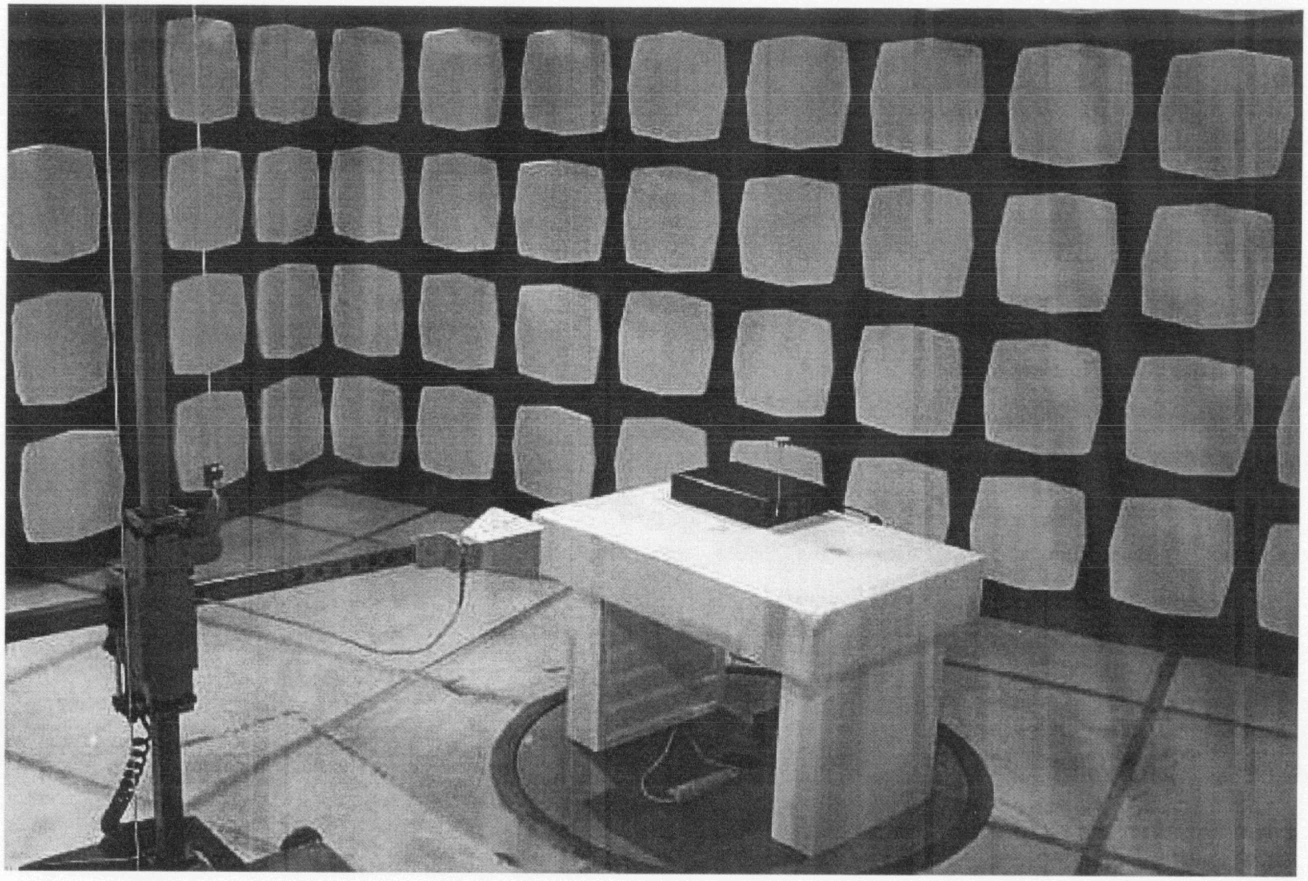
  UWB Bandwidth
  Radiated EMI, UWB Specific Requirements
  Radiated EMI in GPS Bands
  Peak EMI Within a 50 MHz Bandwidth
  AC Mains Line-Conducted Disturbance
  Specialized (Conducted Antenna Terminal, Fully Anechoic)

- Both devices are FCC compliant, based on the measurement procedures established by the FCC

Test Plan Reference

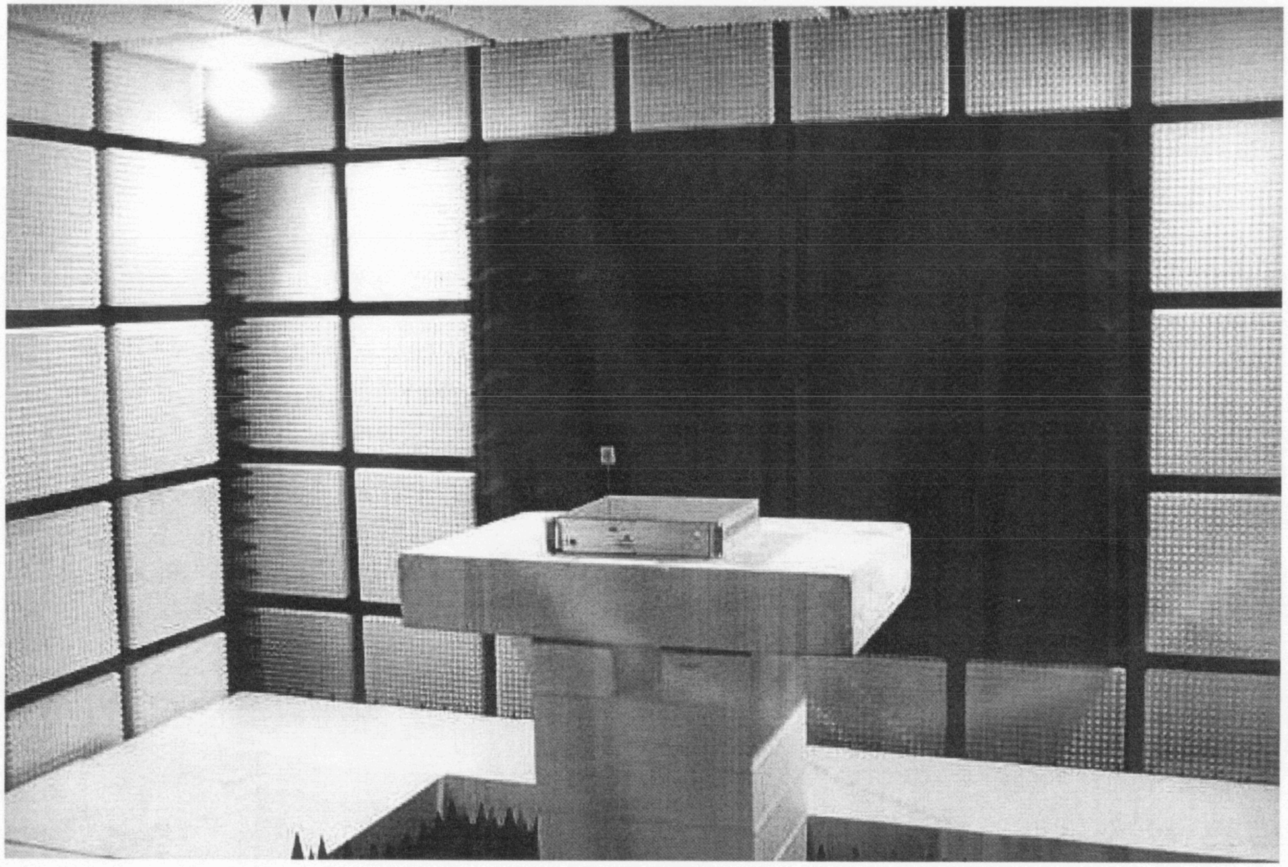
FCC CFR 47, Part 15, Subpart F	Code of Federal Regulations, Part 15 Subpart F: Ultra-Wideband Operation
FCC ET Docket 98-153, FCC 02-48 First R&O	Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmissions Systems: First Report & Order
ANSI C63.4: 1992	Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
FCC CFR 47, Part 15, Subpart C	Code of Federal Regulations, Part 15 Subpart C: Intentional Radiators
FCC CFR 47, Part 15, Subpart A	Code of Federal Regulations, Part 15 Subpart A: General
CISPR 16-1	C.I.S.P.R. Specification for Radio Interference Measuring Apparatus and Measurement Methods

Mandatory Test Environments



1m/3m Semi-Anechoic Chamber (RE)
RF Shielded Chamber (CE)

Alternative Test Environments

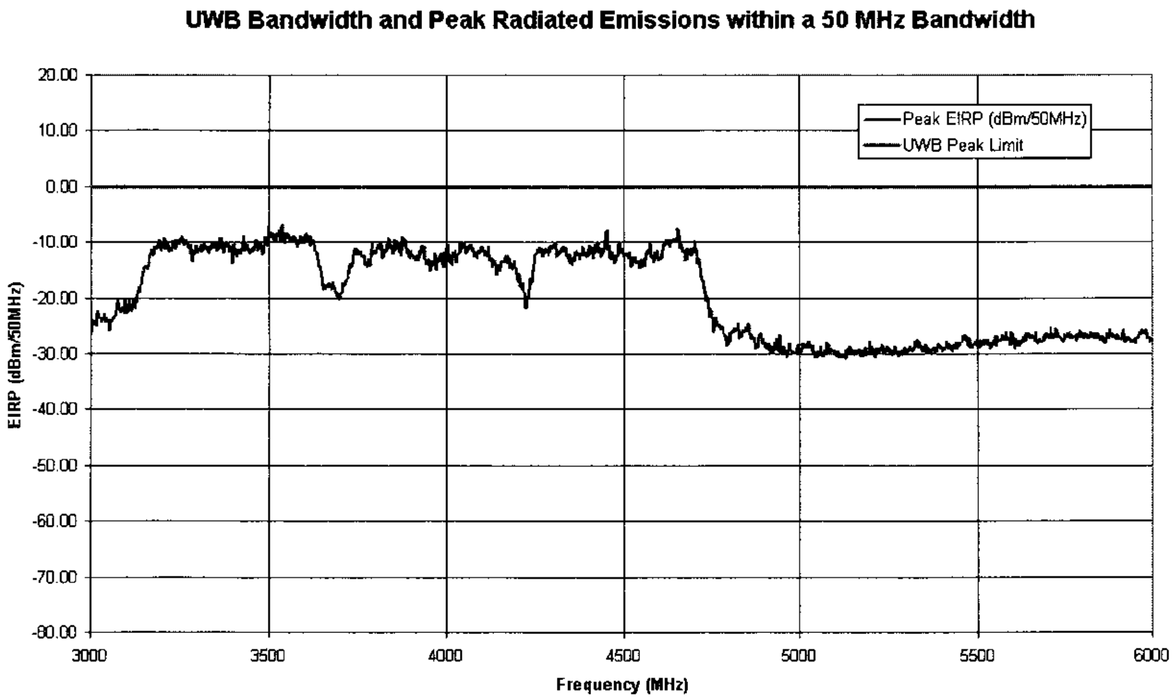


1m/3m Fully-Anechoic Chamber (RE)
Conducted Antenna Terminal Bench (CE)

Device and Measurement Configuration

- The equipment under test physical setup was done as prescribed in ANSI C63.4
- The equipment under test was operating in accordance with its intended usage as per FCC 2-48 First R&O
- The equipment under test was configured to transmit at the mandatory data rate of 110 Mbps
- The EMI Limits were in accordance with FCC Part 15, Subpart F adjusted for the appropriate test distances and resolution bandwidth (if applicable)

UWB Bandwidth and Peak Radiated Emissions within a 50 MHz BW

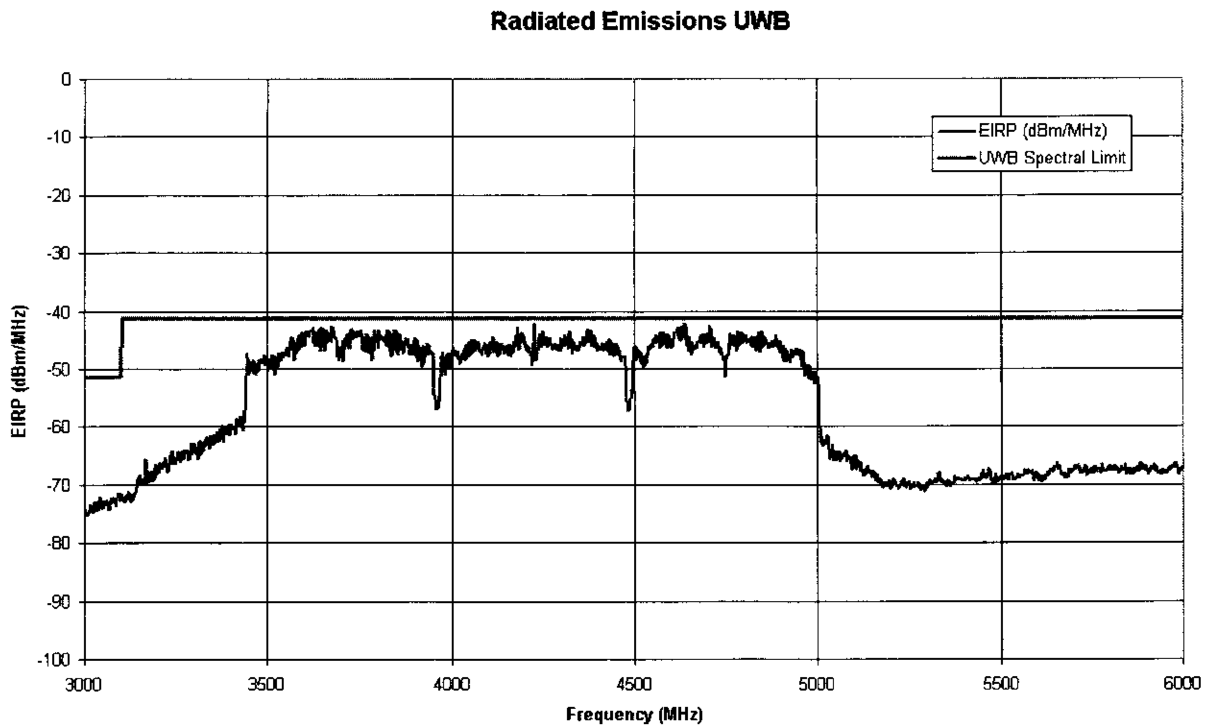


<u>Radio Sample 1</u>

Test Distance:	1m
Detector:	PEAK
RBW/VBW:	3 MHz/3 MHz
Meas. Time:	1 ms
Emissions:	< Limit
UWB BW:	> 500 MHz

Note: Data normalized to 3m test environment and 50 MHz RBW for limit comparison.

Radiated Emissions UWB



<u>Radio Sample 2</u>

Test Distance: 1m
Detector: RMS
RBW/VBW: 1 MHz/3 MHz
Meas. Time: 1 ms
Emissions: < Limit

Note: Data normalized to 3m test environment for limit comparison.

Summary

- Representative data was presented for two radio samples that were shown to be compliant with the most challenging of the UWB measurement test procedures
- Additional EMI measurements (LF digital measurements) in accordance with FCC Part 15, Subpart C Intentional Radiators were performed
- Additional EMI measurements (HF harmonic measurements) in accordance with FCC Part 15, Subpart F UWB Operation were performed
- A series of fully anechoic chamber tests and conducted antenna terminal tests were also performed to further prove compliance in an alternative measurement environment
- Both devices are FCC compliant, based on the measurement procedures established by the FCC

Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [Multi-band OFDM Physical Layer Proposal Response to no Voters]
Date Submitted: [11 January, 2004]
Source: [Presenter 1: Roberto Aiello] Company [Staccato Communications]
[Presenter 2:Gadi Shor] Company [Wisair Corporation]
[Presenter 3:Naiel Askar] Company [General Atomics]

[see page 2,3 for the complete list of company names, authors, and supporters]

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Voice:[858-642-0111], FAX: [858-642-0161], E-Mail: [roberto@staccatocommunications.com]

Re: [This submission is in response to the IEEE P802.15 Alternate PHY Call for Proposal (doc. 02/372r8) that was issued on January 17, 2003.]

Abstract: [This document describes the Multi-band OFDM proposal for IEEE 802.15 TG3a.]

Purpose: [To address the concerns raised by the no voters in the Nov03 meeting.]

Authors of the MB-OFDM Proposal

from 17 affiliated companies/organizations

Femto Devices: J. Cheah
FOCUS Enhancements: K. Boehlke
General Atomics: N. Askar, S. Lin, D. Furuno, D. Peters, G. Rogerson, M. Walker
Institute for Infocomm Research: F. Chin, Madhukumar, X. Peng, Sivanand
Intel: J. Foerster, V. Somayazulu, S. Roy, E. Green, K. Tinsley, C. Brabenac, D. Leeper, M. Ho
Mitsubishi Electric: A. F. Molisch, Y.-P. Nakache, P. Orlik, J. Zhang
Panasonic: S. Mo
Philips: C. Razzell, D. Birru, B. Redman-White, S. Kerry
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Samsung Electronics: M. Park
SONY: E. Fujita, K. Watanabe, K. Tanaka, M. Suzuki, S. Saito, J. Iwasaki, B. Huang
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ST Microelectronics: D. Hélal, P. Rouzet, R. Cattenoz, C. Cattaneo, L. Rouault, N. Rinaldi,, L. Blazevic, C. Devaucelle, L. Smaïni, S. Chaillou
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Alereon: J. Kelly, M. Pendergrass, Kevin Shelby, Shrenik Patel, Vern Brethour, Tom Matheney
University of Minnesota: A. H. Tewfik, E. Saberinia
Wisair: G. Shor, Y. Knobel, D. Yaish, S. Goldenberg, A. Krause, E. Wineberger, R. Zack, B. Blumer, Z. Rubin, D. Meshulam, A. Freund

In addition, the following 29 affiliated companies support this proposal:

Adamya Computing Technologies: S.Shetty
Asahi: Shin Higuchi
Broadcom: J. Karaoguz
Cypress Semiconductor: Drew Harrington
Fujitsu Microelectronics America, Inc: A. Agrawal
Furaxa: E. Goldberg
Hewlett Packard: M. Fidler
Infineon: Y. Rashi
JAALAA: A. Anandakumar
Maxim: C. O'Connor
Microsoft: A. Hassan
NEC Electronics: T. Saito
Nokia: P. A. Ranta
Prancer: Frank Byers
Realtek Semiconductor Corp: T. Chou
RFDomus: A. Mantovani
RF Micro Devices: Baker Scott
SiWorks: R. Bertschmann
SVC Wireless: A. Yang
Synopsys: Xerxes Wania
TDK: P. Carson
TRDA: M. Tanahashi
tZero: O. Unsal
Unwired Connect: David D. Edwin
UWB Wireless: R. Caiming Qui
Vestel: Haluk Gokmen
VIA Networking Technologies: Chuanwei Liu / Walton Li
WiQuest: Matthew B. Shoemake
Wisme: N. Y. Lee

No Vote Response

- Most responses referred to the FCC certification and interference issues.
  - Extensive resources were allocated to resolve this issue
  - Significant progress has been made in the analysis and measurements of interference and building good working relationship with the FCC to alleviate any concerns
- Some responses addressed the IP position of the MBOFDM author companies
  - 5 companies with significant IP positions issued statements for royalty free licensing
  - Most companies have filed RAND statements
- Time to market
  - Quicker to market than alternatives
- Other specific issues were also responded to

FCC Certification and Interference Issue

Introduction

- **The issue**: How is the average power measured for a MB-OFDM waveform?
  - Is it considered a 'hopper'?
  - Does it need to reduce average Tx power compared to impulse based UWB waveforms?
- **FCC response**: Julius Knapp issued a statement that the issue is *about interference and not about rules language interpretation*
- **Our response**: Members of the MBOA took several steps to address the interference concerns
  - ***Detailed simulations*** of a PHY layer reflective of a broadband FSS system completed
  - ***Analysis*** of parameters effecting coexistence between UWB devices and FSS systems completed
  - Analysis of ***Amplitude Probability Distribution*** (APD) for MB-OFDM and other pulsed systems completed
  - ***Measurements*** of interference into a real FSS receiver completed
    - Includes MB-OFDM, WGN, and pulsed-UWB systems
  - Results in this briefing were shown to FCC